Power Technologies Sector

The role of the power technologies sector is expanding in response to many factors, including the nation's growing environmental concerns, widespread utility restructuring, and the increasing trends toward community sustainability and environmental preservation. These opportunities are being addressed through the use of renewable energy options such as photovoltaics, concentrated solar power, wind energy, geothermal energy, hydropower, and biomass power. Increasing use of clean energy will drastically change the power sector by diversifying energy sources, reducing greenhouse gas emissions and pollutants, improving the reliability of service, and lowering energy costs. The development and deployment of renewable energy and energy efficiency technologies will accelerate the integration of alternative energy.

SEP SPECIAL PROJECTS FUNDING FOR THE POWER TECHNOLOGIES SECTOR:

1996	**N/A**
1997	**$1,352,000**
1998	**$1,736,084**
1999	**$1,775,855**
total:	**$4.9 million**

The mission of the Office of Power Technologies (OPT) is to lead the national effort to support renewable technology efforts and to assist in the development of clean, credible, and reliable power technologies for the 21st century. By working with utilities, industries, laboratories, and other stakeholders, OPT maximizes the market potential of renewable energy and energy efficiency technologies. The majority of OPT's Special Projects focus on the construction of demonstration sites and test modules to test the feasibility of the various

THE DATA COLLECTED FROM SMALL-SCALE PV MODULES ARE USED TO ESTABLISH A VARIETY OF LARGER SCALE APPLICATIONS ACROSS THE NATION. ONCE INSTALLED, PV SYSTEMS CAN OPERATE CONTINUOUSLY WITH LITTLE MAINTENANCE AND MINIMAL OPERATING COSTS.

POSSIBLE APPLICATIONS FOR SMALL-SCALE PV SYSTEMS INCLUDE RESIDENTIAL HOMES.

alternative power sources and to educate the public on these technologies. Additionally, OPT's Special Projects are tailored to meet a region's specific power opportunities. Photovoltaics are emphasized in sunnier climates, biomass is explored in farming communities, and geothermal heat is tested in areas where underground heat exchange loops can be easily installed.

PHOTOVOLTAICS

Photovoltaics (PV) systems, or solar cells, are among the most widely used renewable energy sources. PV systems convert light energy into electrical energy and, in addition to being less taxing on the environment, they require little or no maintenance and have low operating costs. PV systems are already commonplace in everyday life in the form of the simple systems that power calculators. The goal of OPT is to make larger, more complex systems an integral factor in powering communications, lighting, water, and electrical systems.

Photovoltaics for Utility Systems Applications Project (PVUSA) is a national public/private partnership that is assessing and demonstrating the viability of PV systems through a network of smaller projects. The projects conduct demonstration-related research and, as of 1997, operated two dozen grid-tied PV systems across the nation with a combined capacity of 2.3 megawatts. In the first nine years of use, PVUSA generated enough energy to offset the equivalent of 18,000 barrels of oil, or the same as the annual electricity consumption of 2,000 homes. PVUSA is a noteworthy project, both because of its scope, which includes long and

THE CHOPTANK ELEMENTARY SCHOOL, IN CAMBRIDGE, MARYLAND, EXPECTS TO SAVE $400,000 IN ENERGY AND MAINTENANCE COSTS OVER THE NEXT 20 YEARS AS A RESULT OF ITS GHP USE.

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short-term demonstrations, and its funding, which is supported by a partnership of 17 public and private utility and government agency sponsors. Partially funded by SEP Special Projects, the ***Small Systems Test Center***, located in Davis, **California**, has enabled PVUSA to perform short-term evaluations of today's commercially promising rooftop scale PV systems. Through SEP Special Projects funding in **Florida**, ***PVUSA*** tests large-scale PV systems to be used in utility applications. The results of these projects are entered into a database which is publicly available on the Internet.

PV systems can be a cost-effective technology for supplying electricity in a variety of remote areas. In **Colorado**, the ***Installation of PV Applications in Sylvan Lake State Park Project*** incorporated PV systems into park construction and performed retrofits on older buildings to provide the park with renewable power. On the remote islands located in the U.S. Territory of the **Northern Mariana Islands**, PV systems offer more than just a source of power. The ***Upgrade of Solar Power System for Seismic Monitoring Stations Project*** focused on the modernization of seismic stations on the island of Saipan. Reliable operation of these stations is critical in providing the warning systems which notify the surrounding communities of possible tsunamis and volcanic eruptions. In another example of photovoltaic use increasing public safety, the ***Remote Communication Network Project*** in **New York** successfully utilized PV technology to improve the police communication systems in mountainous regions of the State.

GEOTHERMAL HEAT PUMPS

Geothermal heat pump (GHP) systems use the Earth's natural thermal energy to heat or cool residential, commercial, and institutional buildings. The only additional energy

GHP systems require is the small amount of electricity they employ to concentrate what nature provides and then to circulate high-quality heating and cooling throughout a structure. When used in space heating, GHPs can reduce electricity consumption in homes by as much as 75% and improve indoor air quality.

South Carolina's mild climate and the robust rate of new construction annually render GHP an extremely viable power option for the State. The ***Support Installation of Geothermal Heat Pump and Training for Contractors Project*** was primarily developed to increase public and building industry awareness of geothermal technology and practices. The project established three GHP demonstration sites across the State to be viewed by the public and used for on-site training by architects, builders, installers, and engineers. The project advanced the use of renewable energy sources in mainstream construction and effectively leveraged matching funds, raising $103,000 in funds to supplement the $90,000 Federal grant.

Maryland's first GHP system was installed at the Choptank Elementary School in Cambridge, Maryland. The ***Geothermal Heat Pumps Special Project*** funded an information and learning center complete with an interactive kiosk-style video monitor at the school. The learning center features real-time data from several of the system's monitoring points and includes a history of the system's design and installation.

DURING THE INSTALLATION OF A GEOTHERMAL HEAT PUMP, TWO WORKERS DRILL HOLES TO CREATE GROUND-COUPLED HEAT EXCHANGE LOOPS. HOLES FOR GHP USE MUST BE 4 INCHES IN DIAMETER, AND BETWEEN 125 TO 450 FEET DEEP.

When used in space heating, GHPs can reduce electricity consumption in homes by as much as 75%.

A RESEARCHER EXAMINES WOODCHIPS WHICH WILL BE PROCESSED IN A BIOMASS GASIFIER TO PRODUCE ETHANOL.

A benefit of biomass gasification systems is the ability to adapt to a farm's waste disposal needs at any given time.

BIOMASS

Both crop and livestock farmers realize the importance of environmental preservation, as their very existence is dependent upon the land. Many swine, poultry, and dairy producers are becoming more interested in alternative energy sources to reduce environmental damage and biomass offers an ideal solution. Biomass systems convert a variety of farm wastes into gases, which are then used to generate energy. This technology can be widely applied across many agriculture and livestock industries. In the Mid-Atlantic region, and specifically the Chesapeake Bay area, there is an excess phosphorous problem as a result of the poultry industry. In an effort to address regional concerns and mitigate related soil problems, the ***Small Scale Biomass Project*** in **Maryland** established a model for generating electricity using a co-fired system. The system would primarily utilize poultry waste, but would also use switch grass and wood chips as fuel.

A benefit of biomass gasification systems is the ability to adapt to a farm's waste disposal needs at any given time. The **Indiana** ***Feedstock Diversification for Downshaft Channel Gasifier Project*** constructed a second-generation biomass gasifier. The gasifier processed about one ton per day of feedstock and produce wastes, then fueled an engine which generated 40 kilowatts of electricity per day. This mobile test module was used to test wood chips, switch grass, alfalfa, and manure and is now used as a demonstration module at sites across the State.

In addition to utilizing a variety of farm-waste types, biomass systems often incorporate several technologies for operation. In

Mississippi, the ***Biomass Power Project*** developed a farm model which utilized an aerobic digester to manage farm wastes and produce methane. The methane was then used to provide energy and hot water to the farm. The model also incorporated fuel cell and propane technology to provide an example of a self-sufficient farm which incorporates a variety of renewable energy sources.

Another model which effectively demonstrated methane capture was **Iowa**'s ***Alternate Energy Production Project***, which focused on livestock operations. The project leveraged four times ($400,000) the Federal grant of $100,000, and created the methane capture demonstration site. The site was a 4,800-sow, farrow-to-wean operation and produced 40%–60% of the farm's electricity. Livestock wastes were captured and used to heat the digester, which produced 646,488 kilowatts hours of electricity annually. This generation is equivalent to the annual consumption of 76 U.S. homes. Additionally, this rate would avoid emissions of 808 tons of carbon dioxide as compared to coal combustion.

WIND ENERGY

As more States, utilities, and other groups consider using wind energy to generate electricity, they require more accurate information to determine the cost-effectiveness of wind installations at specific sites. Much of the existing U.S. wind data is in the form of meteorological data from the National Weather Service stations, which are often

AN INCREASE IN THE NUMBER OF WIND RESEARCH PROJECTS PERFORMED AT SITES ACROSS THE NATION HAS PRODUCED A LARGER POOL OF QUALIFIED TURBINE TECHNICIANS. THESE SKILLED WORKERS WILL BE A CRUCIAL FACTOR IN WIDESPREAD USE OF WIND ENERGY.

Increasing use of alternative energy will dramatically change the power sector by diversifying energy sources, reducing greenhouse gas emissions and pollutants, improving the reliability of service, and lowering energy costs.

Wind energy systems could generate electricity at one-quarter the cost of diesel generators in many Alaskan villages.

ULTIMATELY, WIND RESEARCHERS SEE WIND FARMS, LIKE THIS ONE IN VERMONT, SUPPLYING A SIGNIFICANT PORTION OF THE NATION'S POWER.

located in urban areas or near airports. This data is insufficient for the detailed resource measurement information needed to determine the feasibility of a wind installation facility at a particular site. Special Projects assist in obtaining this specific information through the support of wind assessments across the nation.

In **New Hampshire**, the ***Wind Resource Project*** created a unique partnership between a private utility company, a State college, and the Federal government. Using SEP Special Project and private funding, four monitoring towers were installed and monitored by students at Plymouth State College. The Natural Science Department used this project to educate students about wind energy techniques, and the students were then designated as official subcontractors. After the initial project was completed, Northeast Utilities provided additional funding to gather data for another two years.

Resource measurement in **Alaska** is aiding remote villages in determining if wind energy systems can reduce their dependence on small, expensive, and difficult to operate diesel power plants. In many villages the cost of electric power produced by diesel generators can be as much as 40 cents per kilowatt hour. Yet, experience in Alaska has shown that where wind energy systems are used, the cost ranges between 10 to 15 cents per kilowatt hour. As many as 90 villages in the State are thought to have resources adequate to warrant the installation of wind energy systems. SEP Special Projects funding and resources from the State of Alaska are now helping five villages determine if wind energy systems are appropriate energy sources for their needs.

Many States found that the ***Wind Resource Projects*** increased the quality of data required to site wind energy facilities and enlarged the work force that can conduct

skilled wind resource assessments. The *New Jersey Wind Resource Assessment Project* was conducted by the Liberty Science Center in Jersey City, **New Jersey**. Two wind-speed, wind-direction, and temperature monitors were installed at two different heights. During the study period, the data indicated that the wind speed was greater during the day than at night and that wind production at those sites was sufficient to satisfy only residential demands. The data was made available to the public via computer disk to encourage broader use of the information.

Wind resource assessments are being conducted across the country and this proliferation is due, in part, to SEP Special Projects. In **New Mexico**, Special Projects established six sites to gather wind data for a two-year observation period. The State also collaborated with **Colorado** and **Hawaii** to assist them in establishing their programs. Wind resource assessment projects were also conducted in **Arizona** and **Vermont**, providing diverse information on the feasibility of wind power throughout the nation.

HYDROGEN

Hydrogen is attractive as an alternate engine fuel because it is extremely clean, renewable, abundant, and potentially affordable. In an effort to accelerate market penetration of this fuel type, **California** conducted the *Development of a Variable Gaseous Fuel Engine to Facilitate Penetration of Hydrogen in the Transportation Sector Project.* Through SEP Special Projects funding, the University of California's College of Engineering (Riverside) developed a variable gaseous fuel engine that burns any mixture of natural gas and hydrogen in a pressurized tank. One of the most important aspects of this project was the selection and testing of both thermal and laser fuel sensors, which are an integral part of the variable gaseous fuel system.